REPORT

ON THE

CAWNPORE EXPERIMENTAL FARM OPERATIONS

DURING THE RABI SEASON, 1881-82.

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FROM

THE DIRECTOR, DEPT. OF AGRICULTURE AND COMMERCE,

N.-W. PROVINCES AND OUDH,

To

THE OFFG. SECRETARY TO GOVERNMENT.

N.-W. PROVINCES AND OUDH.

Dated Cawnpore, the 28th July, 1882.

SIR,

I HAVE the honor to submit Mr. Fuller's report on the rabi operations at the Cawnpore Experimental Farm. He was throughout in managing charge, holding the same position towards me with respect to the Farm as Messrs. Duthie and Ridley hold with respect to the Botanical and Horticultural Gardens. The post of Overseer was filled by Mr. Spitteler, acting under Mr. Fuller's orders.

2. The main experiments during the season were in wheat cultivation. The results go far to discredit the extremely low estimate which has been accepted of the productiveness of Indian agriculture. The land of the Farm is generally poor and nowhere of exceptional fertility. Only one-fourth of the area sown had been specially manured for this crop, and a very moderate amount of irrigation—two waterings to a fourth and three to the remainder of the area—was given. Yet the crop on 16·8 acres averaged more than 23 bushels to the acre, and on one unmanured plot, which had only been watered twice, reached the very high outturn of over 44 bushels.

The only advantage it enjoyed over ordinary native cultivation was the use of a soil-inverting plough, against which should be set the disadvantages in some cases of exceptionally poor soil, unsuccesful experiments, and double-cropping.

3. The danger of error in generalizing from single instances was to a certain extent guarded against by conducting the more important experiments in duplicate on plots situated at some distance from each other in different parts of the Farm. The generally close correspondence of the results adds considerably to their value. The conclusion arrived at from experiments with natural manures, and confirmed by separate experiments with artificial manures on the Ville system and by a scientific analysis of the soil, is, if warranted, one of extreme practical importance. Of the four elements which manure adds to the life of plants it appears that the soil of the Farm is seriously wanting in one only—nitrogen. Omitting nitrogen from the artificial manures, no increase was given by a combination of phosphorus, potash, and lime. When nitrogen to the extent of three-fourths of the requirements of the crop was added, the weight of outturn in grain was two and a half times as great as that of the unmanured plot, and of straw nearly three times. Mr. Fuller classes bone-dust as one of the manures yielding phosphoric acid ; but the superior yield it gave when compared with calcic superphosphate, in which the phosphorus is in a far more available form, points strongly to the conclusion that its fertilizing qualities were due principally to the nitrogen it contains. Allowing 4 per cent. of nitrogen to the constitution of bone-dust, the amount contributed to the reserves of that element already present in the soil by 360lb. of bone-dust would be more than 14lb., or about a third of the whole requirements of the crop. The low outturn secured by 160 maunds of whole dung when compared with the outturn produced by the ashes of the same quantity is explained by the fact that in the dung-manured plots a large proportion of the wheat was consumed by white-ants, for the extirpation of which an earlier watering than could be given is required. A scientific analysis by Mr. Hill, the Meteorological Reporter for these Provinces, showed that while the farm soil has sufficient lime and a larger quantity of potash and phosphorus than typically fertile soils in Europe, it fails in nitrogen only, having 1,483lb. to the top nine inches of an acre, while an average quantity of the same element in Europe is 5,757lb. in the same area.

4. Other facts pointing in the same direction will be found in the report; and if the conclusion is to be accepted as established, it follows that the main problem of practical agriculture in this country is now to supply nitrogen in the form of a cheap manure. Mr. Fuller recommends the use of saltpetre and green soiling by ploughing in a young crop of hemp. There seems to be little doubt that the latter is a very cheap and effective means of fertilization. If saltpetre is of so great a value as these experiments appear to show, it is probable that any artificial restraints on its manufacture act injuriously on the agricultural interests of the country.

5. The great increase in produce which results from early ploughing is almost certainly due to the amount of nitrogen in the form of ammonia which it enables the loosened soil to absorb from the rain, and probably from the air as well. Another conclusion of practical importance is that drainage may do much harm by washing the nitrogen out of the soil. It is not impossible that this may be the cause of the barrenness of ravine tracts, off which the rain drains rapidly instead of being absorbed by the soil.

6. The experiments with different numbers of waterings gave in both series the unexpected result that one watering followed by a weeding gives a higher produce than two waterings, after the second of which the land is allowed to cake. I should however hesitate to accept the result of these experiments as conclusive. Further waterings up to five give a steadily increasing rate of produce.

That well water produced more than canal is probably correctly ascribed to the greater opportuneness with which the farmer can be supplied. The difficulty of obtaining canal water at the time when it was most required completely ruined the sowings of American maize and English carrots and wurzels, and was the cause of the destruction of much of the dung-manured crop by white-ants.

7. It was found that much saving could be effected by thin sowing, provided that it were possible to guarantee the even germination of all the seeds over the whole plot sown. Where this was secured there was not much difference in the outturn of plots sown behind the plough, or by dibbling in a twelfth part of the same amount of seed, or in plots in which every furrow, or only every second or third furrow, had been sown.

8. Of the foreign crops Cape oats were again very successful. Black and white gram and English wheats and barleys proved to be far inferior to native varieties; but as the results from this year's sowings were better than any in preceding years, it is possible that these crops may improve with further acclimatization. The experiment would be of greater interest if the best kinds of Indian wheat were not already as good as any known. Naked barley seems to be an impostor and *Alfalfa* to be only another name of lucerne.

9. The workshops, which for the greater part of the time were in charge of Captain Clibborn, but which it has since been found necessary to combine again with the Farm, turned out a fair number of ploughs, winnowers, and pumps. Negotiations for the manufacture of the Kaisar plough were undertaken with Messrs. Coen and Co. of Agra and Crowley of Allahabad, but without much practical results. Experiments are being made towards adopting a plough better suited to heavy soil than the Kaisar is, and for the improvement of the Farm pump. The Little Giant (a combined thresher and winnower) imported from America, was very successful, though its expense forbids the hope that it will ever be used, unless, which is not at present likely, a number of cultivators will co-operate. Even then it is doubtful whether, unless its construction be materially cheapened, it can be made to do nearly enough work to pay interest on the capital outlay.

I have the honor to be,

SIR,

Your most obedient servant,

W. C. BENETT,

Dir., Dept. of Agri. and Com., N.-W. P. & Oudh.

REPORT

ON THE

OPERATIONS AT THE CAWNPORE EXPERIMENTAL FARM

During the Rabi Season, 1881-82.

THE operations of the half year may be subdivided into (A) Field experiments of a purely agricultural nature, and (B) Experiments with agricultural implements and machinery.

(A.) FIELD EXPERIMENTS.

2. As has been too commonly the case in late years, the season was marked by a deficiency in the rainfall. Ample rain fell in July and August and the tillage of fields intended for rabi crops progressed satisfactorily; but the rain virtually ceased before the commencement of September, and the rainfall of that and of the succeeding month (October) only amounted to ·4 and ·2 of an inch respectively, against a normal quantity of 5·4 and 1·0 inches. Under the circumstances it was surprising that the ground retained sufficient moisture to bring about the proper germination of the seed when sowing time came with the middle of October, and in some cases it was considered advisable to irrigate previously to sowing. This was done however with only a small portion of the farm area, and the crops on high-lying fields, which had lost a portion of the rainfall by surface drainage, suffered considerably from uneven germination. That the natural moisture was sufficient on level land which had been well ploughed is proved by the fact that two adjacent fields, each of about half an acre in extent, yielded crops of wheat at such closely corresponding rates as 1,581lb. and 1,588lb. per acre, although one was sown after irrigation and the other without it, their treatment in other respects being exactly similar.

From November 1st till May 31st the rainfall did not amount to one inch, and of this only ·6 inch fell while the crops were on the ground. This small quantity was of but little practical benefit, being evaporated almost as soon as it fell. The rainfall of the season is shown below :—

Month.	*Rainfall in inches.*	
	Actual.	Normal.
September	0·4	5·41
October	0·2	1·08
Total	0·6	6·49
November	0·0	0·08
December	0·0	0·18
January	0·0	0·74
February	0·2	0·53
March	0·0	0·25
April	0·4	0·15
May	0·3	0·41
Total	0·9	2·34

When there are however facilities for cheap irrigation, such as are enjoyed by the Farm, the occurrence of winter rains is not a matter of importance. Indeed, it is probable that the total absence of fungoid disease (rust, smut, &c.) which characterizes a dry cold weather more than compensates for the expense of having to give (say) three waterings instead of one or two.

3. Measured by the Farm crops the season was an extremely good one, and the outturn obtained from unmanured and not heavily irrigated land would have

been surprising to any one who was not convinced of the natural fertility of Indian soil. The total area under wheat was 16·8 acres, not more than one-fourth of which had received manure during the preceding year. No field received more than three waterings after sowing and a portion (about 4 1 acres) was only watered twice. Yet the average produce of wheat grain per acre was over 1,390lbs. (=17 mds.), the maximum outturn amounting to so high a figure as 2,820lb or 34 mds (=47 bushels). One of the unmanured fields, which had also only received two waterings, yielded at the rate of 2,662lb. or 32 mds. per acre. The crop was not only large in quantity but of excellent quality, and over 50 per cent. of it stood the test of being twice passed through an English separator and may be considered first-class grain. The seed was originally obtained from Muzaffarnagar three years ago and was of the same kind as that which has been largely distributed by this Department during the past two years.

4. The cultivation of the half year comprised experiments on—

(1) the effect of different manures ;
(2) irrigation ;
(3) thin sowing ;
(4) new varieties of seed.

The cultivation of American maize as a cold-weather crop, and of English carrots and mangels, formed part of the programme, and these crops were sown in September. Unfortunately however canal water ran short (the canal distributary being closed for repairs), and with the failure of rain all three crops withered and died. The Farm lost in this manner the produce of 3 acres of land, only a portion of which could be resown with wheat. The loss to an ordinary cultivator would of course have been crushing, and may furnish a clue to the reluctance with which many cultivators rely on canal irrigation for crops for which *timely* watering is essential. The cultivation of flax must also be added to the list of experiments. Over an acre of it was grown from Riga seed, and the produce was by no means unsatisfactory. It has not however been broken and scutched as yet, and until these operations have been completed it is impossible to speak with confidence of the quality of the outturn.

4. (i) **Experiments on manures.**—These may be subdivided into (*a*) Experiments forming part of a continuous series on plots set aside for the comparative trial of certain manures over a number of years ; (*b*) Experiments with certain combinations of chemical manures on the lines suggested by M. Georges Ville, the French chemist; (*c*) Special experiments to test the value of phosphoric acid on the farm soil ; (*d*) Special experiments on green soiling.

(*a*) *Experiments forming part of a continuous series.*—It has been already stated in previous reports that two series of plots, each in duplicate, had been marked out for the continuous trial of different manures in the kharif and rabi seasons. By continuous heavy cropping the plots had been reduced to a par as regards natural fertility by the commencement of the season under report, and were therefore fit subjects for experiment. Wheat was the crop grown, and the treatment of the plots, irrespective of manure, is shown in tabular form below :—

Treatment on account of crops experimented with.				*Previous treatment.*		
Ploughing.	Seed and rate per acre.	Irrigation.	Weeding.	Year.	Manure.	Crops.
Twice, with soil-inverting plough.	White wheat at 1¼ md.	Once before sowing (*paleo*) and three times afterwards.	Once.	1879 kharif ...	Nil ...	Cotton.
				1880 „ ...	Nil ...	Maize.
				1881 „ ...	Same as now applied.	Do.

It was unecessary to crop both sets of plots with maize in the kharif preceding the rabi under report, and they bore therefore two crops within the year. The effect of this in lessening the rabi produce must not be lost sight of.

The area of each plot was one-twelfth acre. The manures experimented with and the result per acre is shown below :—

No. of plot.	Manure and rate per acre.	Cost of manure per acre.	Outturn in pounds per acre. Grain. First series (R.)	Grain. Second series (Al.)	Straw. First series (R.)	Straw. Second series (Al.)	Cost of cultivation.*	Value of produce (average of both plots).†
		Rs. a. p.	lb.	lb.	lb.	lb.	R.	Rs.
1	Saltpetre 240 lb. ...	9 0 0	1,242	1,605	1,635	2,160	28·0	42·1
2	Saltpetre 240 lb., bone-dust 360 lb.,	13 8 0	1,395	1,575	1,785	2,124	32 5	43·8
3	Dung 160 mds. ...	9 0 0	918	738	1,080	915	28·0	24·1
4	Dung 160 mds., bone-dust 360 lb.,	13 8 0	846	678	1,155	843	22·5	22 5
5	Dung 160 mds., gypsum 240 lb.,	14 4 0	882	594	1,152	774	23·2	21·7
6	Ashes of 160 mds. dung ...	9 0 0	1,284	978	1,491	1,326	28·0	36·1
7	Bone-dust 360 lb. ...	4 8 0	1,287	1,422	1,509	1,869	23·5	39·6
8	Bone superphosphate 240 lb. ...	14 8 0	1,065	1,170	1,278	1,524	33·5	32·6
9	Gypsum 240 lb. ...	5 4 0	798	912	1,017	1,233	24·2	26·4
10	No manure ...	*Nil*	777	771	1,221	1,113	19·0	23·2

The first point to be checked in this table is the correspondence between the two sets of plots. With this end I compare below (1) the per cent. increase in outturn, (2) the difference in outturn per cent. of each pair of plots and the pair preceding it on the list.

Manure.	*Per cent. increase in grain on outturn of unmanured plot.* First series (R.)	Second series (Al.)	*Difference between the outturn per cent. of each plot and that of the plot preceding it.* First series (R.)	Second series (Al.)
Gypsum	2	18	...	...
Bone superphosphate	37	51	+35	+33
Bone-dust	65	84	+28	+33
Ashes of dung	66	26	+1	—56
Dung and gypsum	13	23	—53	—3
Dung and bone-dust	8	13	—5	—10
Dung	18	5	+10	—8
Saltpetre and bone-dust	79	104	+61	+99
Saltpetre	60	108	—19	+4

* The head "cost of cultivation" includes the following items. :—

	Rs. a. p.
Two ploughings	3 0 0
Clod-crushing	0 8 0
Seed	3 0 0
Sowing	1 2 0
Weeding	2 0 0

	Rs. a. p.
Irrigation—	
Canal dues	1 8 0
Lifting (for four waterings) ...	4 8 0
Making water beds ...	0 2 0
Rent	3 4 0
Manure	Variable.
Total ...	19 0 0

† Calculated at the rate of Rs. 2 per maund for grain and 5 annas per maund for straw.

It will be noticed that the increase per cent. on the unmanured outturn is as a rule larger in the second than in the first series, but the proportionate increase between one plot and another corresponds in both series with tolerable regularity. Considering that this is only the third season in which the two sets of plots have been similarly manured and cropped and that they are situated at a considerable distance apart, the general correspondence between their outturn speaks strongly for the general accuracy of the results.

Taking now the average of the duplicate plots, the results of each manure which was experimented with may be compared as follows, the manures being classified according to the principal ingredient in plant food which they supply :—

	RESULT PER ACRE.					
	PER CENT. IN GROSS OUTTURN.				ACTUAL ON PROFITS.	
	Increase.		*Decrease.*		Increase.	Decrease.
	Grain.	Straw.	Grain.	Straw.		
					Rs.	Rs.
Manures yielding nitrogen.						
Saltpetre	83	62	...	...	9·9	...
Dung	7	...	...	15	...	8·1
Manures yielding phosphoric acid.						
Bone superphosphate	44	20	...	...	...	5·1
Bone-dust	75	44	...	...	11·9	...
Manures yielding nitrogen and phosphoric acid.						
Saltpetre and bone-dust ...	91	67	...	...	6·8	...
Dung and bone-dust	...	...	2	15	...	4·2
Manures yielding lime and potash.						
Gypsum	10	...	...	4	...	2·0
Ashes of dung	46	20	...	...	3·9	...
Manures yielding nitrogen, lime and potash.						
Dung and gypsum	...	...	5	18	...	5·7

The value of the table is very greatly impaired by the lowness of the outturn yielded by all plots to which dung was applied, which is quite abnormal and due to a special cause. The plots having been cropped in the kharíf preceding, it was only possible to apply the manure six weeks before the wheat was sown. It is well known that dung, unless it has lain mixed with the soil through a rainy season, attracts white-ants, and it is for this reason that native cultivators scatter manure on their rabi as well as on their kharíf fields before the commencement of the rains. If dung is applied after the rains have ceased, early irrigation is an absolute necessity as a check to the insects, and in the present case, owing to a failure of canal water, this could not be effected. The plots should have been watered by the end of November at latest ; but it was not possible to give the first irrigation until December 20th, by which time a large portion of the crops had been destroyed. The outturns of the plots to which dung was applied must therefore be wholly disregarded.

5. Bone-dust and saltpetre stand at the head of the mineral manures, increasing the profits of cultivation by Rs. 12 and Rs. 10 per acre respectively when used singly, but by less than Rs. 7 when used together. Grounds have been given in previous reports for believing that nitrogen is the element most needed by Indian soils, and saltpetre is specially well qualified to supply nitrogen, which constitutes 12 per cent. of

its weight. The 360lb. of saltpetre applied per acre represent therefore nearly 44lb. of nitrogen, which is about the quantity contained in the grain and straw of a good crop of wheat.

The increase given by bone-dust is not so easily accounted for. The element for which bone-dust is generally valued is its phosphoric acid ; but bone superphosphate also contains this, and in a much more soluble form, without however adding so much to the outturn or even reimbursing its cost. The explanation probably lies in the fact that bone dust contains, in addition to its phosphoric acid, a certain amount of nitrogen (about 4 per cent.) valuable to Indian soils for its own sake as well as for enabling the phosphoric acid to exert its full effect, which in the absence of nitrogen it cannot do. If this is the case, the phosphoric acid in ground bones is, so far as Indian soils are concerned, of subordinate importance to the nitrogen which they contain ; and this view is strengthened by the fact that when saltpetre and bone-dust were used together and the value of the latter was confined to its phosphoric acid, the outturn showed but little increase over that yielded by saltpetre alone.

6. Light is thrown on the subject from another side by an analysis of the soil of one of the unmanured plots which was kindly made for me by Mr. S. A. Hill, B.Sc., Meteorological Reporter to Government. The sample was collected after the rabi crop had been cut and cleared, equal quantities of soil being taken from the first, second, and third three inches of depth and carefully mixed. The sample therefore represents the soil of the upper nine inches of ground. I subjoin Mr. Hill's report, adding columns to show the actual amount in pounds of the more important ingredients which the analysis indicates as present in the upper nine inches of an acre, and also the quantity which is consumed by a wheat crop of 20 mds. grain and 25 mds. straw :—

The soil when received was moist,* brown in color, and contained a few roots of wheat or some other cereal. When dried in the air its color was light brownish grey. Roughly washed in a very slow stream of water it left about 80 per cent. reddish sand with a very few small nodules of kankar. By careful and continued washing a minute quantity of the dense dark-brown mineral *wolfran* (tungstate of iron and manganese) could be extracted. The specific granity of a carefully powdered and selected sample was 2 54, or nearly the same as that of pure quartz A chemical analysis of the soil gave the following results :—

		Per cent.	=lb. in the upper 9 inches of an acre.	Amount consumed by a crop of wheat.
			lb.	lb.
Volatile, 3 66	Moisture expelled at 250°F. ...	0 60		
	Combined water expelled at a red heat.	2·03		
	Organic matter	0 16		
	Carbon dioxide	0·16		
	Ammonia	None.		
	Nitrogen pentoxide	0·11	5,717·25 (=1,483 nitrogen)	173·5 (=45 nitrogen.)
Soluble in Hydrochloric acid, 12·59.	Chlorine	Trace.		
	Sulphur trioxide	Do.		
	Silica and tungstic oxide ...	0·13		
	Phosphorus pentoxide ...	0·51	26,136·0 (=11,411·5 phosphorus.)	18 5 (=8·1 phosphorus.)
	Alumina	4·18		
	Oxides of iron and manganese	5·56		
	Lime	0·90	46,391·4	12·3
	Magnesia	0·91		
	Potash	0 32	16,335·0	27
	Soda	0·08		
Clay decomposed by sulphuric acid 6·29.	Alumnia and oxide of iron ...	2·92		
	Silica	3·37		
	Insoluble sand	78·10		
	Total ...	100·04		

The soil appears to have plenty of phosphate, but to be weak in potash and very deficient in organic matter.

It is generally accepted that the only ingredients in plant food with which practical agriculture need concern itself are, in the order of increasing importance, lime,

* There had been a slight shower of rain two days before the sample was taken.

potash, phosphoric pentoxide (or acid), and nitrogen. A tolerable safe conclusion as to the richness of the Farm soil in the three first named may be drawn from a comparison of the quantities contained by other soils known to be fertile :—

	* A very fertile alluvial soil in East Friesland.	† A fertile soil near Gottingen.	† A loam producing remarkably fine crops of wheat.	The Farm soil.
Percentage contained of lime ...	6·3	2·1	·83	·9
Ditto potash ...	·21	trace	2·8	·32
Ditto phosphoric pentoxide ...	·47	·2	·24	·57

These figures show very clearly that the Farm soil is in no way deficient either in potash or lime and contains considerably above the ordinary amount of phosphoric acid. Phosphatic manures cannot therefore be expected to produce much effect, and this is certainly borne out by the experience of the two last years. In the season under report dung ashes produced a larger increase in the outturn than even the costly superphosphate, owing probably to the salts of potash which they contain.

But the analysis shows the Farm soil to be very deficient in nitrogen, perhaps the most essential of all the ingredients in plant food. The nitrogen contained in organic matter is not assimilable in that form, and as the soil contains no ammonia, the only source of nitrogen available is nitric pentoxide. It will be seen that the amount of this substance present in the soil is vastly in excess of the requirements of a single crop, but only a small proportion of the whole assumes a sufficiently soluble form each year to be of practical benefit, and the best indication of the condition of the Farm soil as regards its nitrogen supply will be furnished by comparison with other soils. The presence of nitric pentoxide in Indian soils results from the rapid reduction of ammonia, which is characteristic of a tropical climates ; and in European soils nitrogen is found in most part in the form of ammonia, only a portion of which is reduced each year.

The percentage of ammonia found in nine samples of arable soil quoted in Johnstones and Cameron's Agricultural Geology varies from ·116 to ·170, the average being ·144. This is equal to 5757·6lb. of nitrogen per acre, or to over four times as much as is contained in the Farm soil. It may also be mentioned that the nitrogen contained in the upper nine inches of soil on a field at the Rothamsted Experimental Farm which had been continuously cropped with wheat for 22 years—unmanured—amounted to 2,507lb., or nearly double the Farm supply. Theory therefore amply bears out the experience that the manures which are most productive are those supplying nitrogen.

7. (*b*) *Experiments with certain combinations of mineral manures on the Ville system.*—These experiments were suggested by the work of M. Georges Ville entitled "Artificial Manures," which has been recently translated by Mr. W. Crookes, F.R.S. Their object was to discover by actual experiment the direction in which the deficiency of the Farm soil lay, this being effected by using certain manurial substances in varying combinations, so as to be able to judge of the effect of excluding each one of them from the mixture. The crop experimented with was wheat, and the general treatment of the plots was exactly similar to that of the plots dealt with in the preceding sections. Details of the manures applied and of the results per acre are appended. The size of each plot was one-twenty-fourth of an acre :—

* From Johnstone and Cameron's Agricultural Geology.

† From Sibson's Agricultural Chemistry.

Number of plot.	Manures applied, with rate per acre.	Plant food substance which the manure represented.		Outturn per acre in pounds.		Increase per cent. on unmanured plot.	
		Amount supplied by the manure per acre.	Amount consumed by a crop of 20 mds. wheat.	Grain.	Straw.	Grain.	Straw.
	lbs.	lbs.	lbs.				
I.	Calcic superphosphate 180 Ammonic chloride 138, Potassic sulphate 90. Calcic sulphate 96,	Phosphorus 9·6 Nitrogen 36·0 Potassium 25·8 (=potash 31·1) Calcium 28·2 (=lime 39·4)	8·1 45·0 22·4 (=potash 27·0) 8·7 (=lime 12·3)	2,142	3,066	150	185
II.	Ditto less calcic superphosphate.	Less phosphorus.	...	1,896	2,652	121	146
III.	Ditto less ammonic chloride.	Less nitrogen ...	...	840	1,152	*Nil*	7
IV.	Ditto less potassic sulphate.	„ potassium...	...	1,908	2,778	122	158
V.	Ditto less calcic sulphate,	„ calcium ...	...	1,812	2,412	111	124
VI.	No manure ...	*Nil* ...	...	858	1,074	...	...

It is very seldom that an agricultural experiment yields such clear and decisive results as are obtained here. It has been noticed before that the four substances conveyed to the soil in these manures are the only ones with which agriculture need concern itself. By supplying the crop with nitrogen to the amount of three-fourths of its requirements, the outturn is more than doubled; omit nitrogen and no increase is obtained, although all the other manures may be given. The omission of phosphoric acid from the combination causes a decrease of only 12 per cent., of potash 11 per cent., and of lime 16 per cent. in the outturn of grain: and allowing for the disturbing causes which can never be entirely eliminated from field experiments, these figures so nearly agree as to render it probable that the effect of omitting any one of those three substances is much the same.

I may note that this is the second season of the application of these manures, they having been used for a crop of maize in the preceding kharif.

8. (c) *Special experiments on the effect of phosphoric acid as a manure on the Farm soil.*—Three experiments were made with the object of testing the value of phosphoric acid when used in combination with nitrogenous manure—that is to say, under the most favourable circumstances. The area under experiment was of considerable size, amounting to nearly two acres. The treatment of the fields, irrespective of manure, is summarized below:—

No. of experiment.	Treatment on account of crop experimented with.				Previous treatment.		
	Ploughing.	Seed and rate per acre.	Irrigation.	Weeding.	Year.	Manure.	Crop.
I.	Twice; in July and September.	White wheat 1½ maund.	Sown dry; watered three times after germination.	Once	1878-79 ... 1879 80 .. 1880-81 ...	*Nil* ... Guano 3½ mds. *Nil.*	Juar. Wheat. Sorgho.
II.	Three times ...	Ditto ...	Sown after irrigation, and watered three times after germination.	Once	1878-79 ... 1879-80 .. 1880-81 ...	*Nil* ... Indigo ploughed in. *Nil* ...	Indigo. Wheat. Sorgho.
III.	Four times ...	Ditto ...	Ditto ...	Once	1878-79 ... 1879-80 ... 1880-81 ...	Dung ... *Nil* .. Guano ...	Maize. *Nil.* Sugarcane.

The manures which were applied and the results obtained were as follows :—

No. of experiment.	Area of plot.	Manure applied and rate per acre.	Outturn per acre in pounds		Percentage increase on plot which received no phosphoric acid.	
			Grain.	Straw.	Grain.	Straw.
	Acre					
I	·41	Dung 140 mds ... ... * Bone superphosphate 288lb. ...	1,568	2,491	A slight decrease.	A slight decrease.
	·41	Dung 140 mds. .. ... No superphosphate	1,588	2,322	...	...
II.	·22	Dung 155 mds .. . †Mineral superphosphate 388lb.	1,978	3,008	24	36
	·47	Dung 140 mds. ... ... No superphosphate	1,584	2,220	...	...
III.	·22	Bone superphosphate 290 lb ...	2,820	Not weighed.	13	...
	·22	Mineral superphosphate 290lb. ...	2,555		3	...
	·50	*Nil*	2,486		...	...

The general excellence of outturn is remarkable, the average of the seven fields being 2,082lb. of wheat grain to the acre (=25 mds. or 36 bushels) worth, with the straw, about Rs. 62.

The results of the experiments are somewhat conflicting, the application of phosphoric acid giving in one case no increase whatever, and an increase in the other case of 24, 13, and 3 per cent. A certain amount of discrepancy must however be expected in the results of experiments on so large a scale, and from the outturn of the first and third experiments the conclusion follows that the application of phosphotic manures to the Farm land produces very little—if any—effect. The excess in the produce of the manured plot in experiment No. II. is probably due to other causes. Superphosphate cannot be prepared at Cawnpore at a lower cost than Rs. 4-12 per maund, and the application of 300lb. of it requires therefore an increase of at least 6 mds. of grain and a corresponding quantity of straw per acre merely to reimburse its cost. This means an increase of 36 per cent. on the produce of the unmanured plot in experiment No. II., and therefore, were the whole of the increase ascribed to the action of the superphosphate, there would still be a considerable loss on its use.

9. (*d*) *Special experiments in green soiling.*—If the conclusion be accepted that the most prominent deficiency in the Farm soil is in its nitrogen supply, the practical question arises as to how this supply can be increased. A certain amount of nitrogen is derived by the soil from the rainfall in the form of ammonia, the number of pounds of nitrogen which an acre annually receives in this way being estimated at 7 in England, but as high as 20 in some parts of Southern Europe. It is probable that in India the amount is still higher, since the air at some seasons of the year is known to be very highly charged† with ammonia. Under these circumstances it is more than ever important that every facility be afforded for the rapid absorption of the rainfall by the soil, and this accounts for the benefit which results from ploughing up land at the very commencement of the rains, even although it is not to be sown until four months later. The ammonia is in the heat of India oxidized into nitric acid almost as soon as it reaches the earth, and since in this form it can be readily abstracted from the soil by water, it is probable that India owes much of its fertility to the absence of subsoil drainage, which is so marked a feature in this country. The annual loss of nitrogen in drainage water is estimated in England to amount to 15 or 16lb‡ per acre, or to more than double the quantity which is annually received from the rainfall.

* Both the bone and the mineral superphosphate used in this experiment were procured from Dr Waldie of Calcutta, having been manufactured respectively by the action of sulphuric acid on burnt bones and on mineral substances (coprolites) containing phosphoric acid; neither therefore contained any nitrogen

† The amount of ammonia in the rainfall of England is ordinarily about 1·07 parts per million in country districts and from 3 6 to 9 0 in crowded cities, such as Glasgow and London. Angus Smith notices the exceptionally large proportion of 32 35 parts per million as having once occurred in a sample of rain water collected from the impure atmosphere of the City of London But a heavy shower which fell at Lucknow in June, 1882, was ascertained by Major Pitcher to contain as much as 34·Q parts per million

‡ See a paper on the Rain and Drainage waters at Rothamsted printed in the Journal of the Royal Agricultural Society [Vol. XVIII, Pt 1, p. 68].

Looking at the increase in produce which results from ploughing up land in April and allowing it to lie in open furrow through the hot-weather months, the conjecture may be hazarded that possibly the soil may be able to absorb ammonia directly from the air when in loose and porous condition, and this would still further tend to maintain the continuous fertility of the Indian soil.

Coming now to the means of artificially increasing the nitrogen supply, the most obvious of existing resources is cattle dung, the value of which however principally depends on the food which the cattle receive, and is therefore not very great to the Indian cultivator. In that portion of it which is used as fuel the nitrogen is of course entirely lost, and there is a considerable waste in that portion kept as manure from exposure to the influence of the sun and rain. A much more effective source of nitrogen is, as has been already shown, saltpetre, which even at its present price will yield a considerable profit. It is very doubtful however whether a cultivator will ever be induced to purchase his manure, and the manufacture of saltpetre in villages is checked by Customs regulations.

It is possible that a third and much simpler method of increasing the stock of nitrogen may be found in "green soiling"—that is to say, in growing a crop of the leguminous order, cutting it down while green and ploughing it in. According to some authorities plants of this order are able to absorb nitrogen directly from the air, and their tissues become therefore store-houses of atmospheric nitrogen which yield their contents to the soil when allowed to rot in it. Experiments made in the rabi season of last year appeared to give excellent ground for believing that ploughing in a leguminous crop after this fashion does as a matter of fact greatly add to the outturn, and the experiments were repeated with still more marked results in the season under report. Two parallel plots each one-twelfth of an acre were sown with hemp on August 17th ; the hemp was cut down on September 22nd when about 2 feet high and ploughed in with the English plough, the stalks being laid in the furrows exactly as is done with long strawed dung in England. Since rain failed, the plots were watered on September 27th to hasten the decomposition of the hemp, and again on October 20th, when they were ploughed up and sown with wheat. The total cost per acre was not therefore more than Rs. 4-2-0 :—

		Rs.	a.	p.	
Cost of seed (say)	...	0	8	0	At thirty seers to the acre.
„ sowing	...	1	2	0	
„ cutting	...	1	8	0	
„ ploughing in	...	1	0	0	
Total	...	4	2	0	

One of the plots was manured with gypsum at the rate of 120lb. per acre when the hemp was cut, in order to discover whether any benefit would result from the property possessed by this mineral of arresting the volatile compounds of ammonia given off in decomposition.

A third plot, situated next to one of these under hemp, had been under lucerne (also a leguminous crop) for the year preceding, and it is interesting to note how excellent was the crop of wheat yielded by it. The lucerne had been sown in September, 1880, and up to September, 1881, when it was ploughed up to make room for a crop of wheat, it had been cut six times, yielding a total outturn of 280 mds. of green fodder to the acre.

Details of the outturn obtained from all three plots are given in tabular form below. The wheat was in each case watered three times after germination and weeded once :

No. of plot	Specific treatment.	*Outturn per acre in pounds.*		Cost of cultivation.	Value of outturn.
		Grain.	Straw.		
				Rs	Rs.
I.	Green soiled with hemp	1,713	2,328	26 1	50·9
II.	Green soiled with hemp and manured with gypsum at 120lb. to the acre	2,244	3,237	28·9	67·2
III.	Cropped with lucerne for a year previous	1,395	2,127	22·0	42 3

Unfortunately there was no unmanured plot in the same series the outturn of which could be taken as a standard of comparison, since the soil of all the other experimental plots had been somewhat exhausted by a crop of maize in the kharif preceding. There were however two fields at a short distance from the series of experimental plots on which wheat was grown without manure, but otherwise with exactly similar treatment, and the outturn of which may fairly be taken as representing what the hemp plots would have produced had no hemp been grown on them. One of these fields with an area of ·12 acre yielded 1,280lb. of wheat to the acre and the other, with an area of ·62 acres yielded 1,298lb. The agreement between these outturns is all the more striking since the fields were situated at a distance of at least 200 yards from one another. Taking the average of these two outturns, *viz.*, 1,289lb., as the outturn of unmanured land, the increase resulting from the use of hemp as manure and from the effects of a crop of lucerne may be represented as follows :—

Treatment.	Result per acre.	
	Increase per cent in gross outturn of grain.	Increase in actual net profit per acre, making rateable* allowance for straw.
		Rs.
Green soiled with hemp	33	9·4
Ditto and manured with gypsum	74	22·9
Cropped with lucerne	8	4·9

The results therefore appear to leave little doubt of the fact that green soiling with hemp does increase the outturn, especially when gypsum is added. It appears certain that the increase is due to a larger supply of nitrogen, although opinions differ as to whether this is actually drawn from the air or merely concentrated in the upper layer of soil, being drawn up from below by the long tap roots of the hemp plant. The result appears of the highest practical importance, and the trials will be continued on a large scale during the current year. The increase which resulted from previous cropping with lucerne must be due to the same cause and is borne out by the practice in English agriculture of growing a crop of clover before wheat, which is said to often add as much as a quarter (480lb.) to the outturn per acre.

10. (ii) **Experiments on Irrigation.**—Trials were made (*a*) to ascertain the effect of irrigation in increasing the outturn, and (*b*) to obtain fresh information on the vexed question of the relative merits of canal and of well water.

(*a*) *Effect of irrigation in increasing the outturn.*—Experiments were made with wheat on two series of plots, both of which were sown without previous irrigation. The soil of series A was at the time of sowing the dampest on the farm ; on the other hand the soil of series B was considerably drier than the average. By an unfortunate mistake a watering was given to the plot in series B which should have been left unirrigated; so that the outturn of this series of plots merely indicates the result of giving different *numbers* of waterings, and not the result of watering as compared with that of not watering at all. Both series of plots were ploughed three times before sowing and weeded once after the first watering. Series B had borne a crop of wheat unmanured in the preceding year, while series A had enjoyed a year's fallow. The size of the plots in both series was one-twelfth of an acre. The results are shown in the two following tables :—

* The produce of straw on the fields taken as standards of comparison was not weighed.

Series A.

Number of times irrigated, with dates.	Cost of irrigation per acre.	Date when weeded.	Outturn per acre in pounds.		Increase due to irrigation.		
			Grain.	Straw.	Per cent. on produce of irrigated plot. Grain.	Per cent. on produce of irrigated plot. Straw.	Actual in value of produce per acre.
	Rs. a. p.						Rs.
Not watered	*Nil.*	Dec. 19	513	838	...	...	...
Once: Dec. 4th	2 12 0	„ 12	1,671	2,355	225	181	33·4
Twice: Nov. 25th, Feb. 23rd ...	3 14 0	„ 7	1,515	2,165	195	158	25·8
Three times: Nov. 25th, Feb. 3rd, March 4th	5 0 0	„ 7	1,670	2,578	225	207	30·0

A single watering therefore more than trebled the produce and, in addition to paying for itself, increased the profits of cultivation by over Rs. 33. It is remarkable that one watering should have had so great an effect, but the result is corroborated by the outturn of a neighbouring field which reached the high figure of 32 mds. (=40 bushels) to the acre with only two waterings. That one watering should have given a larger outturn than two is also *primâ facie* surprising, but must be explained by the weeding which was given after the first watering and which left the soil of the once-watered plot in open condition right through till harvest, while that of the twice-watered plot was caked by the second irrigation in February. A similar result will be seen in the outturns of the second (B) series :—

Series B.

No. of plot in farm register.	Number of times irrigated, with dates.	Cost of irrigation per acre.	Date of weeding.	Outturn per acre in pounds.		Increase due to irrigating more than once.		
				Grain.	Straw.	Per cent. on produce of once watered plot. Grain.	Per cent. on produce of once watered plot. Straw.	Actual in net profit per acre.
		Rs. a. p.						Rs.
B.b.4	*Once*: Nov. 12th ...	2 12 0	Nov. 25	696	1,158	...	...	...
B.b.5	*Twice*: Nov. 12th, Feb. 20th,	3 14 0	„ 25	513	948	Decrease	Decrease	Decrease
B.b.3	3 *times*: Nov. 12th, Dec. 20th, Feb. 28th.	5 0 0	„ 25	921	1,635	32	41	2·3
B.b.2	4 *times*: Nov. 12th, Dec. 20th, Feb. 1st, Feb. 28th.	6 2 0	„ 25	1,104	1,821	58	57	6·4
B.b.1	5 *times*: Nov. 12th, Dec. 20th, Jan. 19th, Feb. 15th, March 4th.	7 4 0	„ 25	1,209	1,788	73	54	7·6

This was the third year in which these plots had been cropped with wheat unmanured, and the outturns are in consequence small. Two waterings again gave a poorer return than one, and this fact may be considered finally proved by the coincidence of the results of two independent experiments. It is not usual amongst native cultivators to give a weeding to rabi crops, although the experience of the last three years has taught nothing so clearly as the immense benefit which results from it in saving of water. It will be noticed that each watering over two in number not only paid for itself, but produced a very considerable profit.

11. (*b*) *Relative merits of canal and well water.*—An excellent opportunity was afforded for contrasting the results of using canal and well water for irrigation by a cultivator's field situated a short distance outside the Farm enclosure, and about 200 yards from the canal distributary, in which there was a *kucha* well regularly used for irrigation. So soon as the field had been sown, an arrangement was made with the cultivator by which he was to water one half of the field from his well when irrigation was required and leave it to the Farm to water the remaining portion from the canal as nearly on the same date as possible. In order to prevent neglect on his part a liberal rate was fixed according to which the produce was to be valued when cut, cleaned and weighed

by the Farm. The crop which had been sown was the mixture of barley and gram known as *bejhra* with rape (*sarson*) in lines. The area of the well-irrigated portion was ·24, and of the canal-irrigated portion ·28 of an acre. The result is given in the following table:—

Plot.	Number of waterings.	Date of watering.	Date of weeding.	Outturn per acre in pounds.			Value of outturn per acre.
				Bejhra.		Rapeseed.	
				Grain.	Straw.		
Canal-irrigated ...	3	November 14th ... December 24th ... February 16th ..	November 20	1,109	1,412	101	31·6
Well-irrigated ...	3	November 11th ... December 10th ... February 16th ..	November 22	1,312	2,031	137	39·6

The result is certainly surprising, and it is unfortunate that it was not possible to arrange for the conduct of a duplicate experiment. If there was any apparent advantage in situation, it was on the side of the canal-irrigated plot. It may be added that the experiment had not even been thought of at the time when the field was being sown.

I attribute the difference without hesitation to the delay of 14 days in giving the December watering, which arose from the canal supply having failed at that time. The damage which resulted from this failure to the experimental manure plots has been already noticed. A great factor in the influence of water on a growing crop is the *timeliness of its supply*, and it is in this respect that canals are least satisfactory. Hence perhaps the lowness of the rate which cultivators are prepared to pay for canal water compared with either its real value or with the cost of drawing it from a well, and hence too the not uncommon occurrence of well irrigation close under the bank of a canal distributary.

12. (iii) **Experiments on thin sowing.**—The effect was tried (*a*) of dibbling in wheat seed by hand instead of sowing it in the ordinary way, and (*b*) of sowing the seed in every second and every third furrow, instead of in every furrow, as is usually done.

The plot which was sown by dibbling measured one-twelfth of an acre and formed a portion of a field, the remaining part of which (·22 acre) was sown in the ordinary way. In dibbling, the grains were dropped into little holes made with the finger, two grains to each hole, the holes being six inches apart in the same line, and the lines at a distance of one foot apart. In sowing as ordinarily effected the seed was dropped behind a country plough and covered by the earth thrown up from the next furrow; there was therefore a line of plants to each furrow or at a distance of 3 inches apart. In dibbling 5 seers would sow an acre, while for sowing in the ordinary fashion 60 seers are required. Both plots had been manured with 155 maunds dung and 388lb. superphosphate to the acre,—were sown after the ground had been moistened by irrigation,—were three times watered subsequently and once weeded. The results were as follows:—

Method of sowing.	*Seed used per acre.*		*Outturn per acre in pounds.*		Value of outturn per acre.
	Amount.	Cost.	Grain.	Straw.	
	Seers.	Rs. a. p.			Rs.
Behind the plough in ordinary fashion,	60	3 0 0	1,978	3,008	60·8
Dibbled by hand	5	0 4 0	1,986	2,412	57·8

The close correspondence of the outturns of grain is very extraordinary and indicates that the produce represents the real capacity of the field, not to be increased by adding to the number of plants per acre. Dibbling however occasioned a considerable loss in straw (20 per cent.), as indeed was to be expected. Adding the value of the saving in seed (Rs. 2·75) to that of the outturn of the dibbled plot, we obtain Rs. 60·5 as against Rs. 60·0 (the value of the gross produce of the plot sown in the usual fashion), and the net result of dibbling was therefore a gain of eight annas.

The results of sowing in every second and in every third furrow closely agree with the foregoing. In this case it was necessary to sow the seed without previous irrigation, and since the soil was not sufficiently moist germination was very uneven. In the portion of the field sown in every furrow as usual the large amount of seed used compensated for the failure of a large portion of it to germinate, and the result was a crop of 15¾ mds. of grain to the acre on a field measuring ·43 of an acre. On the other two plots the crop was a failure owing to frequent bare patches. Selecting however a small portion of each plot in which germination had been fairly regular, the following results were obtained :—

Method of sowing.	*Seed used per acre.*		*Outturn per acre in pounds.*		Value of outturn per acre.
	Amount.	Cost.	Grain.	Straw.	
	Seers.	Rs. a. p.			Rs.
Every third furrow	15	0 12 0	1,265	1,943	38·4
Every second furrow	30	1 8 0	1,340	2,027	40·6
Every furrow (as usually done) ...	60	3 0 0	1,295	1,862	39·0

Making allowances for errors of experiment, which were intensified by the small size of the thinly-sown plots, the results are practically identical. There can be little doubt therefore that the amount of wheat seed usually sown per acre is at least ten times in excess of the quantity which would be sufficient if all the grains germinated. The extra expenditure of some Rs. 2-8 per acre in seed may be considered as an insurance against loss from uneven germination either by reason of badness of seed or the unequal distribution of moisture in the soil. It is a question however whether the saving of grain which would be effected would not compensate for the trouble of hand-picking seed and obviating in this way all possibility of loss from the first of these causes, and experiments in this direction will be continued.

The individual wheat plants on the thinly-sown plots were of course much finer than where sprung from thickly-sown seed. Some plants bore as many as 49 stalks with an average of 36 fully formed grains to each ear, or at the rate of over 1,700 fold. I did not notice however that there was any difference in the quality of the *cleaned* grain, though the *average* quality was undoubtedly better.

13. **(iv) Experiments with new varieties of seed.**—*Cape oats.*—These again succeeded well. The seed was obtained in 1880 from Australia, only as much being received as would fill a small envelope, and a small plot cultivated during the rabi season of 1880-81 gave a return at the rate of 2,219 lb. (=27 mds.) grain and 3,993 lb. (=49 mds.) straw to the acre. During the season under report it was grown on a larger scale, sufficient seed being in stock to sow, although thinly, ·26 of an acre. The land had been manured with dung at the rate of 100 mds. to the acre, was irrigated before sowing and three times subsequently. One weeding was given. The yield per acre was 1,706 lb. (=20¾ mds.) grain and 2,198 lb. (=26¾ mds.) straw, which is a very satisfactory outturn, although considerably less than that obtained in the preceding year. The cultivation then was however on so very small a scale (the plot only measuring a few square yards) that its results cannot be upheld as a reliable indication of the outturn per acre, and on the other hand the

produce in the season under report would have been larger had the seed been sown somewhat thicker. The purpose for which oats seem to promise best is that of producing green fodder in the cold-weather months rather than as a grain crop. A large quantity of oats is grown with this object in the Meerut Division. There is now sufficient seed of the Cape variety in hand to enable some experiments being made next rabi season and test its capabilities as a fodder plant.

Black and white gram.—The large white-grained variety of gram (known as the "kabuli") and the black-grained gram were tried against the ordinary brown-grained kind with the following results:—

Variety of gram.	Area of plot.	*Outturn per acre in pounds.*		*Difference per cent. from outturn of common variety.*	
		Grain.	Straw.	Grain.	Straw.
	Acres.				
White	·01	602	1,204	—68	—40
Black	·02	1,249	1,249	—33	—33
Common	·2	1,862	1,932	...	...

The plots received two waterings after sowing and one weeding. No manure was used. The outturn of the common variety was extremely good compared with that of the other two kinds, the better quality of which would not compensate for the deficiency in their produce.

English wheats, barleys and oats.—Trial was made of two varieties of wheat, three varieties of barley, and three varieties of oats, specially selected by Messrs. Sutton and Sons of Reading. Plots of wheat from Farm seed and of barley from country seed purchased in the bazar were also grown for comparison. The field had been manured with 100 mds. dung and was irrigated before sowing. The number of waterings given after sowing in each case are shown in the table which follows. One weeding was given. The area of the plots varied from ·1 to ·03 of an acre:—

Name of crop.	Name of variety.	Number of waterings given after germination.	*Outturn per acre in pounds.*	
			Grain.	Straw.
Wheat ...	English, Rough chaff	5	114	1,230
	English, Red bearded	4	283	1,385
	Farm	3	1,757	2,562
Barley ...	English, Peerless	3	741	2,198
	English, Beardless	3	803	1,843
	English, Golden melon	3	1,000	1,828
	Farm	3	1,591	1,319
Oats ...	English, Black Tartary	4	87	1,866
	English, Lincolnshire Poland ...	4	208	3,889
	English, Early blossom	4	102	3,026

In face of the excellence of indigenous wheats and barleys the attempt to introduce English varieties possesses little practical interest. It is worth noting however that this is the first season in which any produce whatever has been gained from English wheat seed, the trials of the two years preceding having resulted in complete failure. It will be interesting to see whether the acclimatized produce will give a better return next year.

Naked barley (Hordeum gymnodistichon) from Kotgarh.—A rather imaginative account of the excellence of this barley was lately sent to the Calcutta Agri.-Horti. Society by Captain F. Pogson and printed in the Society's Proceedings for August 25th, 1881. The difference between it and ordinary barley lies in the fact that its

flower scales do not adhere to the grain so as to form a continuous husk, but drop off in threshing, leaving the grain naked like that of wheat. There is therefore a less difference between its gross and its net weight It is known by the vernacular name of "Rasuli" or "Paighambari," indicating apparently its introduction from Arabia. Its ears may bear either two rows (*var.* distichon) or six rows (*var.* hexastichon) of grains. A field of the former sub-variety was grown on the farm in the rabi of 1880-81 and gave an outturn of 21 mds. grain to the acre, which was 50 per cent. less than the outturn of good ordinary barley under similar circumstances. At the suggestion of the Government of India, a fresh trial was made during the rabi under report with seed procured from Kotgarh through Captain Pogson. This turned out to be of the six-rowed sub-variety, but yielded an outturn of only 10 maunds to the acre, a little more than half of the yield from very indifferent seed of the ordinary kind grown side by side with it under similar treatment.

South American lucerne (Alfalfa).—A quantity of seed of this well-known fodder plant was obtained through the kindness of H. B. M.'s Consul at Venezuela, but turned out to be almost exactly similar to the lucerne, which has become acclimatized in this country. Like many other fodder crops it bears in its own country an extraordinary reputation for resisting drought, but when brought to the test of an Indian hot weather it proved itself much inferior to lucerne from Indian seed, yielding 50 per cent. less green fodder.

(B) EXPERIMENTS WITH AGRICULTURAL IMPLEMENTS AND MACHINERY.

14. During the half-year under report the Agricultural Workshops were dissociated from the Farm and placed under the orders of Captain J. Clibborn, B.S.C., Executive Engineer then attached to the Department. They have since been retransferred to the Farm. The number of implements sent out between November 1st, 1881 and May 31st, 1882 is shown below:—

Ploughs.			*Winnowers.*	*Pumps.*
Sold.	Given away.	Total.	Sold.	Sold.
168	9	177	9	16

34 of the ploughs were manufactured by Messrs. Coen and Co. of Agra for the Department, the balance having been up in the Farm workshops. I understand that Messrs. Coen and Co. have also sold a considerable number independently of this Department. The sale is however very small at present compared with the proved utility of a plough by which the surface soil is inverted as well as stirred, and the undoubted suitability of the departmental implement for light soils, such as obtain throughout a great portion of the Provinces. For heavier soils it is probable that ploughs of English or American manufacture will be superior to anything that can be made up in this country, and during the half year experiments were conducted which ended in the modification of two ploughs, one English (Ransome's B. F. O.) and another American (Watt's steel plough), so as to render them more suitable for native requirements, and they are now both admirably fitted for ploughing heavy loam or clay lands, provided good bullocks are available, such as are in general use in the districts of the Meerut division. A limited number of ploughs of both these patterns is now in stock for sale.

15. Amongst trials of machinery conducted during the half year, those of threshing and winnowing machines deserve especial notice.

Threshing.—Repeated experiments have proved that a pair of bullocks driven by a coolie will tread out on an average 2 mds. of wheat grain in a day of eight hours. Allowing 2 annas as the wage of the coolie and 3 annas for the bullocks, which will cover the cost of the extra food they receive when in active work, the cost of threshing out a maund of wheat comes to 2 5 annas. This is by no means high, and the drawbacks

to the process are (1) its slowness, which leaves the wheat lying for a long time in the threshing-floor exposed to the chances of rain or hail ; and (2) the peculiar earthy smell and flavour which the grain acquires and which is a serious check to its sale in the English market. In order to test the advantages offered by machinery for threshing, an American combined thresher and cleaner was purchased, that manufactured by Messrs. Heebner and Sons of the United States and known as the Little Giant No. 3. Its price in America was only 124 dollars, but when landed in Cawnpore its cost amounted to Rs. 557. Rs. 180 must be added to this as the price of a four-bullock gin which is required to drive it, but which was already available on the Farm ; so that the total cost of the machine was close upon Rs. 740. To work it for eight hours a day the following labour was required :—

	Rs.	a.	p.	Rs.	a.	p.
6 pairs bullocks, two for relief ...	@ 0	3	0	= 1	2	0
4 drivers	@ 0	2	0	= 0	8	0
2 feeders	@ 0	2	0	= 0	4	0
2 women	@ 0	1	6	= 0	3	0
				2	1	0

Four careful experiments extending over 23 hours proved that the machine will thresh and clean at least 20 maunds in a day ; so that, allowing nothing for interest on outlay and wear and tear, the cost per maund only comes to 1·9 for threshing *and winnowing*. The cost of winnowing by machine as a separate process amounts to 4·7 pie per maund, and the total cost of threshing by bullock-treading and of winnowing will be 2·9 annas per maund. The threshing machine effected therefore a saving of 1 anna per maund, and it would therefore require to work off nearly 1,800 maunds in order to repay the 15 per cent. on its cost for interest on outlay and wear and tear. The machine was undoubtedly cheap, but was of anything but good materials and workmanship and required constant repairs. On the other hand I believe that its outturn might be increased to at least 30 maunds a day with a little practice. For short periods of a quarter of an hour I have worked it at the rate of 90 maunds a day, but with great strain on the bullocks and risk to the machinery.

16. *Winnowing*,—Experiments were made to contrast the work of the English machines manufactured by Dell of Mark Lane and Ransome of Ipswich, costing from Rs. 200 to Rs. 250 apiece, with that of the one manufactured in the Farm workshops and sold at Rs. 35. I should mention however that the Ransome's winnower was of an old pattern and is greatly inferior to the machines now turned out by this firm. The cost of working each winnower was found to be—

	Rs.	a.	p.	Rs.	a.	p.
3 coolies	@ 0	2	0	0	6	0
3 women	@ 0	1	6	0	4	6
				0	10	6

The result of the trials is shown below :—

	Maunds of grain cleaned per day of eight hours.	Cost of cleaning per maund.
	Mds.	Pies.
Dell's winnower	36	4 7
Ransome's "	16	10 5
Farm "	19	8·8

The Farm implement came out therefore very creditably, and as soon as certain alterations now under trial have been made in its driving gear it will be still more efficient.

J. B. FULLER,

Asst. Dir., Dept. of Agri. and Commerce, N.-W. P. and Oudh,
In Charge Government Experimental Farm, Cawnpore.

ORDERS OF GOVERNMENT.

No. 1558 of 1882.

From

The OFFG. SECRETARY to GOVERNMENT,
N.-W. Provinces and Oudh,

To

The DIRECTOR of AGRICULTURE and COMMERCE,
N.-W. Provinces and Oudh.

Dated Naini Tal, the 2nd September, 1882.

Sir,

Revenue Department.

I am directed to acknowledge the receipt of your No. 1115A., dated 9th August, 1882, with which you submit Mr. Fuller's report on the rabi operations of the Cawnpore Experimental Farm during the season 1881-82.

2. Mr. Fuller has as usual given a full, clear, and interesting account of the nature of the experiments conducted and of the results obtained. The operations of the half-year are sub-divided into—(A.) Field experiments of a purely agricultural nature : and (B.) Experiments with agricultural implements and machinery.

3. Under (A.), experiments were tried on the effect of—(1) different manures, (2) irrigation, (3) thing sowing, (4) new varieties of seed. The main experiments were made in the cultivation of wheat, and the results go to discredit the low estimate that has generally been accepted of the productiveness of Indian agriculture. The experiments also go to show that the chief requisite for fertility wanting in Indian soil is nitrogen; and if this conclusion prove to be correct, one main problem of practical agriculture in this country would be to supply nitrogen in the form of a cheap manure. The result of further inquiry and experiment will be awaited with interest.

4. Trials were made with irrigation (*a*) to ascertain the effect of irrigation in increasing the outturn, (*b*) to obtain fresh information on the vexed question of the relative merits of canal and of well-water. Under (*a*) it was found that a single watering more than trebled the produce. One watering followed by a weeding gave a higher produce than two waterings, after the second of which the land is allowed to cake. You hesitate, however, to accept the result of these experiments as conclusive. Well-irrigated land gave an outturn per acre of the value of Rs. 39·6, while the value of the outturn of canal-irrigated land under the same conditions was Rs. 31·6 only. The difference is ascribed to canal water not being obtainable at the proper time. Mr. Fuller remarks—"A great factor in the influence of water on a growing crop is the timeliness of its supply, and it is in this respect that canals are less satisfactory

Hence perhaps the lowness of the rate which cultivators are prepared to pay for canal water, compared with either its real value or the cost of drawing it from a well; and hence too the not uncommon occurrence of well-irrigation close under the bank of a canal distributary." It must not, however, be forgotten that the remark as to timeliness of supply may not unfrequently be applicable to some of the land which is irrigated from a well, and for which the cultivator has to wait his turn in using the well.

5. The experiments on thin sowing consisted of (*a*) dibbling in wheat seed by hand, instead of sowing it in the ordinary way; and (*b*) sowing the seed in every second and every third furrow, instead of in every furrow as is usually done. In dibbling, five seers of seed are required to sow an acre, if every third furrow is sown 15 seers, if every second furrow is sown 30 seers, and under the ordinary method 60 seers are required per acre. In all the cases the outturn was nearly the same. There seems to be little doubt that the amount of wheat seed usually sown per acre is at least ten times in excess of the quantity which would be sufficient if all the grains germinated. The extra expenditure of seed may be reckoned as insurance against uneven germination, and Mr. Fuller thinks it is questionable whether the saving of grain which would be effected by thin sowing would not compensate for the trouble of hand picking seed, all possibility of loss from badness of seed being obviated. But it may be doubted whether ordinary cultivators will readily be induced to pick their seed, or trust those who profess to sell picked seed, and then to adopt the minute process of dibbling.

6 Of the experiments with new varieties of seed, that with Cape oats seems to have been successful, and those with gram, English wheats and barleys, naked barley, and Alfalfa seems to have been of little practical utility.

7. *Experiments with agricultural implements and machinery.*—One hundred and sixty-eight ploughs were sold and nine given away, while nine winnowers and sixteen pumps were sold during the half-year. Efforts are being made to introduce a plough suited to heavy soils, and trials with an American threshing and winnowing machine gave interesting results. You seem to be doubtful, however, whether the machine is likely to come into common use and to pay expenses, in which case experiment with it is to a certain extent futile.

8. In conclusion, I am to acknowledge the services of Mr. Fuller as manager of the Farm during the half-year. The report will, as usual, be published in the *Gazette.*

I have the honor to be,

SIR,

Your most obedient servant,

J. R. REID,

Offg. Secretary to Government,

N.-W. Provinces and Oudh.

No. 1559.

COPY, with copy of the report, forwarded to the Superintendent, Government Press, for publication in the *North-Western Provinces and Oudh Gazette.*

F. BAKER,

Under-Secy. to Govt., N.-W. P. and Oudh.